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Diversity receiver having cross coupled channel parameter estimation

The present invention relates to a diversity receiver having multiple antenna receiving branches.

The present invention also relates to a mobile radio communication device provided with such a diversity receiver, a method wherein a signal is received through multiple antenna receiving branches, and relates to signals suited for applying the method.

Such a diversity receiver is known from JP-A-04-185130. The known diversity receiver has two RF antenna receiving branches. Each RF branch comprises an antenna, such that the two antennas are spatially separated at such a mutual distance that the antennas receive virtually non-correlated signals. In the known diversity receiver the branches further comprise in succession: filters coupled to the respective antennas, amplifiers, a delay device and a synthesizer or the like. Outputs of the branches are coupled to a combining circuit. The known diversity receiver reduces the effect of multipath distortion and attains a stable reception of received radio channels in a spread spectrum communication environment.

It is a disadvantage of the known diversity receiver that a substantial amount of processing power is required for controlling the reception and selection of the received radio channels.

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It is an object of the present invention to provide a diversity receiver showing more flexibility and enhanced trade-off between processing power and accuracy.

Thereto the diversity receiver according to the invention is characterized in that each branch has means for estimating at least a receiving channel parameter, and that the channel parameter estimating means in one branch are coupled to the channel parameter estimating means in an other branch for using at least a part of the channel parameter estimate in the one branch as an aid for estimating at least a receiving channel parameter in the other branch.

Similarly the method according to the invention is characterized in that in each branch an estimation is made about a received channel, and that channel estimation results from one branch are being used as an aid for estimating the received channel in an other branch.

5 It is an advantage of the diversity receiver and method according to the invention that in those diversity schemes which require knowledge about the channel characteristics, advantage can be taken of the fact that coupling between channel estimating means in the one branch and channel estimating means in an other branch at least partly prevents duplication of diversity processing and calculations. By exchanging information in
10 particular in the form of channel parameter estimate information between various diversity branches, part of the diversity processing and calculations turn out to be redundant if observed from the angle of time. This way the fact is exploited that one antenna takes on a position for which the channel parameter estimates can be determined, while a little earlier or later at least partly the same calculations are made for an other antenna. Such calculations can
15 now be omitted. Or put otherwise, when using the same processing power within an amount of time the channel estimation parameter results will advantageously be more accurate. These advantages also hold for a mobile communication device comprising such a diversity receiver.

One embodiment of the diversity receiver according to the invention is
20 characterized in that the channel parameter estimate in the one branch is used as a starting point for the channel parameter estimate in the other branch.

Without redundancy in calculations and given the same processing power, channel estimates can now be calculated in a shorter amount of time or given an amount of processing time less processing power and calculations are required for acquiring the same
25 results.

Another embodiment of the diversity receiver according to the invention is characterized in that the channel parameter estimate in the one branch provides a coarse channel parameter estimate, which coarse channel parameter estimate is used as a start for the channel parameter estimate in the other branch.

30 This embodiment of the diversity receiver according to the invention leads to more accurate channel estimate results.

Still another embodiment of the diversity receiver according to the invention is characterized in that the estimating means in the other branch are coupled to the estimating

means in said one branch for using at least a part of the channel parameter estimate in the other branch as an aid for estimating the receiving parameter channel in said one branch.

This way the estimating means in the various branches are mutually coupled to one another leading to a multiplicity of mutually exchanged channel parameter estimate information or associated information accordingly providing a multiplicity of advantages.

A further embodiment of the diversity receiver according to the invention is characterized in that the diversity receiver has two antenna receiving branches.

This provides a simple and cost effective embodiment of the diversity receiver according to the invention.

Another advantageous further embodiment of the diversity receiver according to the invention is characterized in that the system is arranged for estimating a time delay between the appearance of a certain channel parameter estimate in the various branches.

At present the diversity receiver and method according to the invention will be elucidated further together with their additional advantages, while reference is being made to the appended drawing, showing schematized embodiments of the diversity receiver according to the invention.

The sole Fig. shows a schematic view of a particular diversity receiver 1 having two antenna receiving branches B1 and B2 with the help whereof a method for receiving diversity signals will be explained. Each branch B1, B2 comprises receiving means, generally referred to as Radio Frequency (RF) receiving means 2, 3. The receiver as shown comprises two respective antennas A1, A2 coupled to the RF means 2, 3 respectively. The RF means 2, 3 generally include (not explicitly shown) either or not embodied in quadrature: filters, (low noise) amplifiers, mixers, oscillators, converters, analog or digital processing means, all as generally known in the relevant art. For example from the RF means 2 and 3 one or more signals are fed to inputs 4 and 5 respectively of channel parameter estimating means 6 and 7 respectively, in order to allow these means 6 and 7 to derive therefrom respective channel parameter quantities on outputs 8 and 9 respectively. Examples of channel parameters are for example the quality of received signals in one or more channels, or the channel transfer functions e.g. amplitudes and phases of each receiving channel in each branch. The channel parameter estimating means 6 and 7 can –at wish also- derive the respective parameter signals from outputs 10 and 11 of the RF means 2 and 3. For example the quality parameters may even be derived from data signals provided by output signals from hard limiters 12 and 13, as shown by dashed lines in the Fig. The channel parameter signals on the outputs 8 and 9 each comprise a measure for the estimate of the received signal

in that particular receiving channel of the branches B1, B2 concerned. When the parameter concerns the channel quality such quality may be the common Received Signal Strength Indication, or shortly RRSI. Another example concerns checksums, used in certain cases in a Digital Enhanced Cordless Telecommunication (DECT) systems. The quality measurement 5 may either be performed continuous or not. By means of the quality signals the diversity device 1 may determine which of the antennas A1, A2 is the best to be selected. This is schematically shown in the Fig. by means of controllable amplifiers 14 and 15 and a summing device 16 coupled to the amplifiers 14 and 15. Often both amplitude and phase information is used to ensure coherent addition of the signals in the summing device 16. In 10 such case the controllable amplifiers 14 and 15 need to perform phase corrections. In fact in a practical embodiment it may well be that amplifiers 14 and 15 align the phases of the received signals, but do not modify the amplitudes of the signals. This process is called "equal gain combining". As described above another example of a channel parameter is the channel transfer function. Like the quality parameter the channel transfer function parameter 15 calculation results may at least partly be exchanged between the channel parameter means 6 and 7. Possibly both the quality parameters and the channel transfer parameters may be exchanged in order to reduce the total amount of calculations for selecting the best antenna A1 or A2.

The channel estimating means 6 in one branch B1 are coupled to the channel 20 estimating means 7 in the other branch B1 for using at least a part of the channel estimate in the one branch B1 as an aid for estimating the receiving channel in the other branch B2. Apart from the fact that one of the channel estimate means 6, 7 is coupled to its counterpart channel estimate means in the other branch for a one way exchange of channel estimate 25 information or of information which can be of help therefor, it is also possible that the means 6, 7 mutually exchange such information at least during a certain period of time. This saves a considerable amount of processing power or leads to an increase of the accuracy of the channel estimates if the processing power remains constant. For example the channel estimate resulting from one of the estimate means 6 or 7 is used as a starting point for processing and calculations made in the other of the channel estimate means 7 or 6 or/and vice versa. It is also possible that the channel estimate calculated by the means 6, 7 in the one 30 branch B1, B2 provides a coarse channel estimate, which coarse channel estimate is used as a starting point for processing and calculations made in the other of the channel estimate means 7, 6 or/and vice versa.

The positions of the antennas A1 and A2 are such that the instantaneous received signals thereon are not correlated. However if with respect to the received signals a time difference not equal to zero is observed then the signals show correlation, which is advantageously used in the system 1. Generally the distance d between the antennas A1 and
5 A2 is much larger than the wavelength of the received signal divided by two in order to acquire optimum antenna diversity results. If the system 1 is positioned in a vehicle moving at a speed v and if the antennas are roughly positioned on a straight line in the direction of motion, then it can be said that channel parameter estimates from the one antenna are used to better estimate the channel for the other antenna, but a time delay of d/v seconds later. In
10 another practical embodiment of the system 1 the delay value of d/v may be estimated explicitly for example in the estimating means 6, 7. The delay value is then used for the estimated channel parameters, to optimally synchronize the estimation process in the various branches.

Although only two branches are shown in the sole Fig. it is also possible to
15 have more than two branches and associated antennas. In that case the respective channel estimating means may at wish exchange channel estimate information or information related thereto, such as intermediate results, or may for example all mutually exchange such information, in order to use at least a part of the channel estimate or related information in one of the branches as an aid for estimating the receiving channel in one of the other
20 branches.

The method explained above can also find application in mobile communication devices or systems, such as car radio or car communication systems. Examples thereof are Orthogonal Frequency Division Multiplexing (OFDM) systems, where diversity generally requires a lot of calculating and processing time, due to the multiplicity of
25 sub-carriers carrying independent data. Other examples are Digital Video Broadband (DVB) systems, such as DVB-T (Terrestrial), ISDB systems, Carrier Detect Multiple Access (CDMA) systems, for instance cellular CDMA; Universal Mobile Telecommunication Systems (UMTS), Global Systems for Mobile communications (GSM) and the mentioned DECT systems. In the case of OFDM signals, the (vector) outputs 10, 11 typically consist of
30 multiple parallel subcarrier signals (e.g. 64 for WLANs, 2k..8k for DVB-T). In that case the branches are repeated for every subcarrier. In the case of direct sequence CDMA, the receiver branches typically form a so called rake receiver. In such case the outputs 10 and 11 each carry vector signals, containing the signals in the various fingers of the rake. The controllable

amplifiers 14, 15 then operate on all finger signals. The addition in summing device 16 then accumulates all signals of all fingers in all branches.